VTX Simulation

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2009-06-02

STATUS OVERVIEW: WORKING IMPLEMENTATIONS

Stand-alone tracking and vertex-finding is working in realistic simulations of Au+Au events with realistic detector response.

Matching between VTX tracks and central arms

DCA determination of tracks from heavy flavor decays

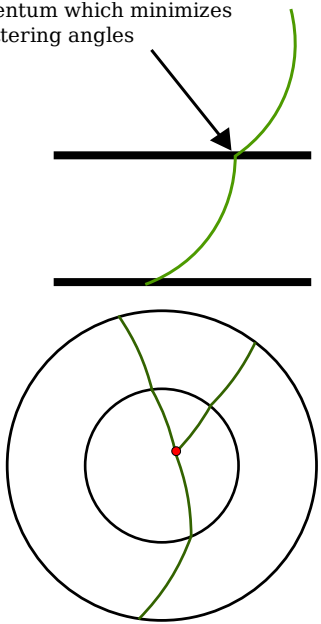
IN PROGRESS

Photon-jet correlation study

Tighter integration of VTX software with the PHENIX infrastructure

Full-scale blind analysis using realistic simulation of VTX (and FVTX)

find momentum which minimizes these scattering angles



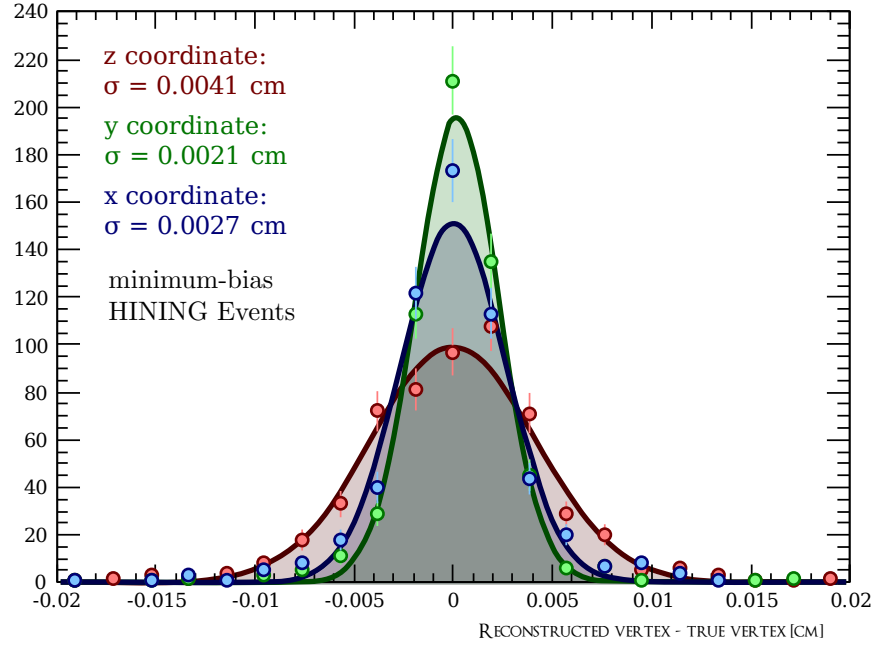
TRACKING

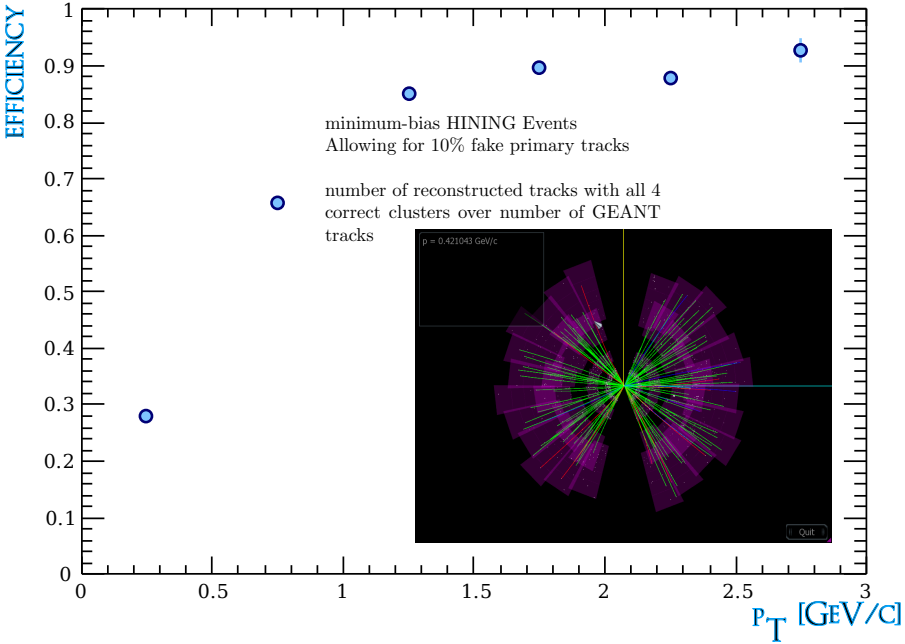
- For a constant magnetic field and given $|\overrightarrow{p}|$ and 2 space points, a unique helix can be contructed.
- At each detector layer the track can be scattered. The interactions are assumed to be elastic.
- Tracks which have small apparent scatters are reconstructed at the momentum which minimizes the scatters.

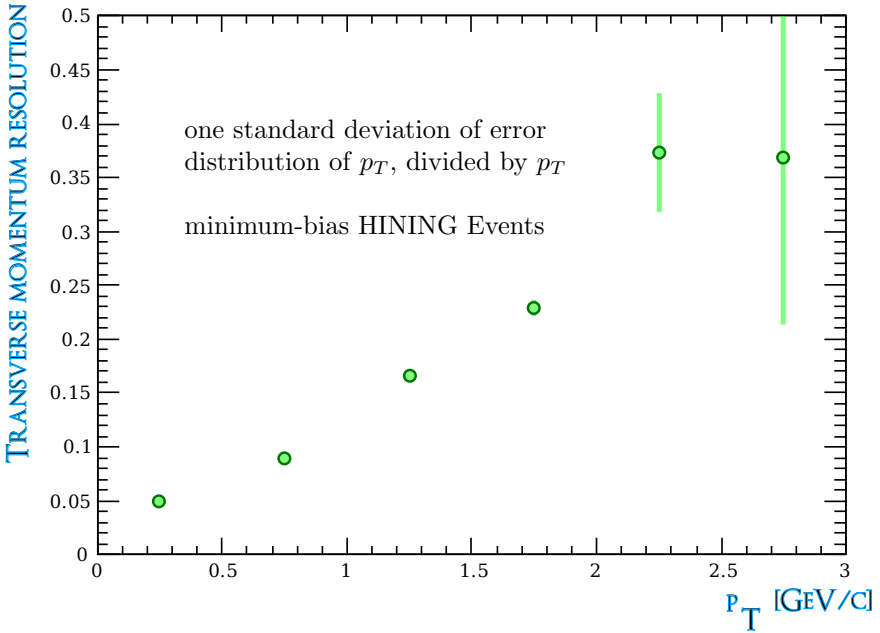
Material thickness and p-dependence of scattering is taken into account

VERTEXING

- Using pixel layers, get initial guess at z vertex in order to filter out many secondary tracks
- Perform tracking though 4 layers for tracks which point roughly to the initial z vertex
- Find vertex position which maximizes total track quality (minimizes apparent scattering angles)


z coordinate:
σ = 0.0041 cm
y coordinate:
σ = 0.0021 cm
x coordinate:
σ = 0.0027 cm
minimum-bias
HINING Events
240
220
200
180
160
140
120
100
80
60
40
20
0
-0.02
-0.015
-0.01
-0.005
0
0.005
0.01
0.015
0.02
RECONSTRUCTED VERTEX - TRUE VERTEX [CM]


EFFICIENCY
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
p_T [GeV/c]
minimum-bias HINING Events
Allowing for 10% fake primary tracks
number of reconstructed tracks with all 4 correct clusters over number of GEANT tracks
p = 0.421043 GeV/c
Quit

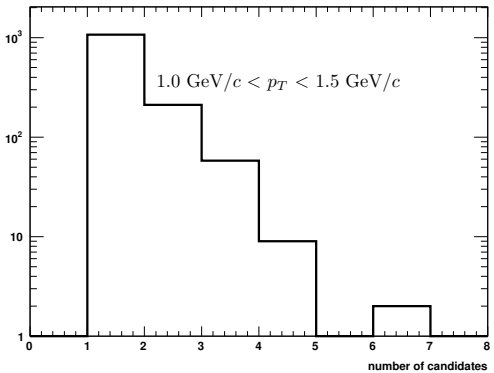

TRANSVERSE MOMENTUM RESOLUTION
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5
3
P T [GEV/C]
one standard deviation of error
distribution of p_T, divided by p_T
minimum-bias HINING Events

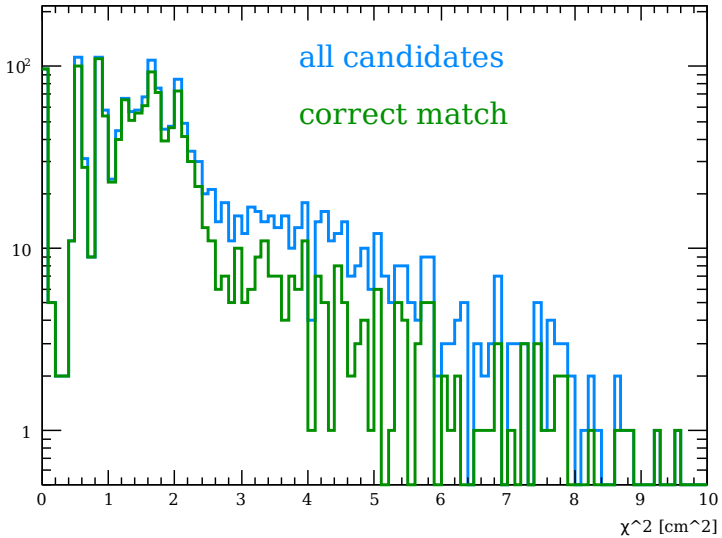
ALGORITHM

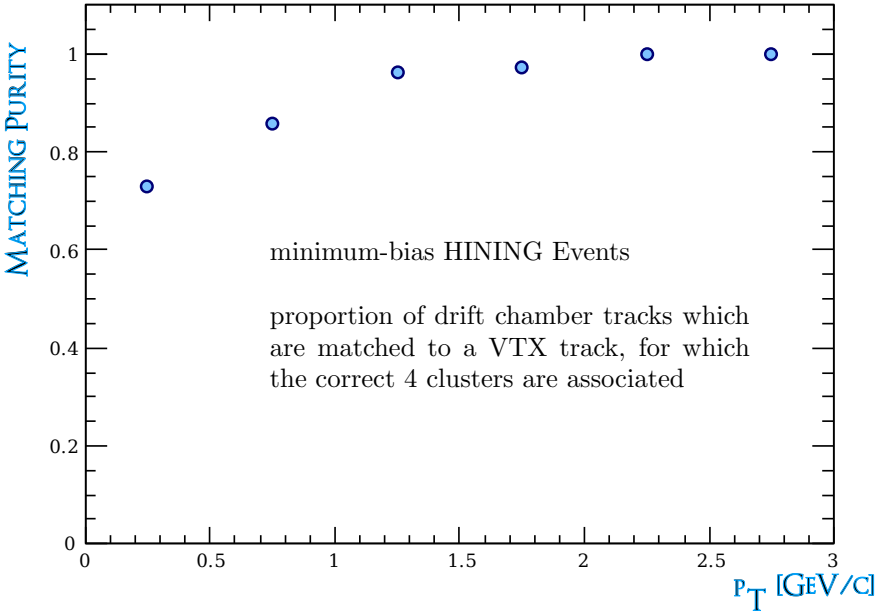
- For each drift chamber track, make a list of candidate VTX tracks by matching in 3D momentum space.
- Project the drift chamber track back to the VTX and calculate the intersection positions with the VTX layers
- Select the candidate which minimizes $\sum_{\text{layers}} |\vec{x}_{\text{cluster}} - \vec{x}_{\text{projection}}|^2$

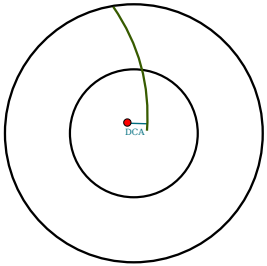
only momentum cut is used in this plot (no position χ^2)

minimum-bias HINING Events



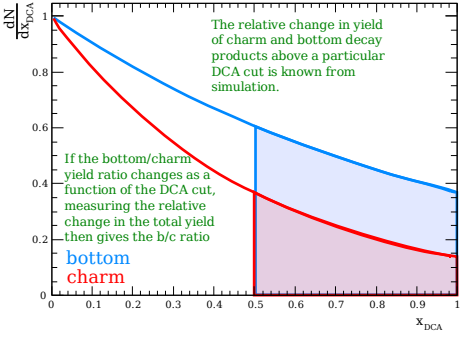

all candidates
correct match
10^2
10
1
0
1
2
3
4
5
6
7
8
9
10
χ^2 [cm^2]


MATCHING PURITY
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
3
minimum-bias HINING Events
proportion of drift chamber tracks which are matched to a VTX track, for which the correct 4 clusters are associated
p_T [GeV/c]



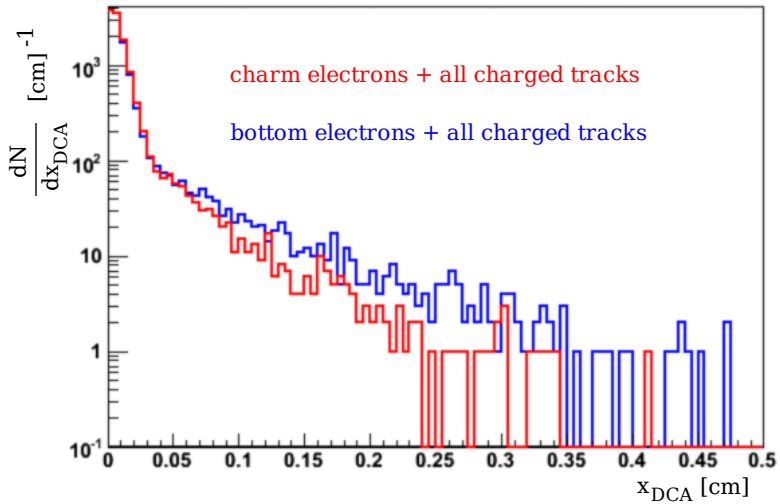
KEY POINTS

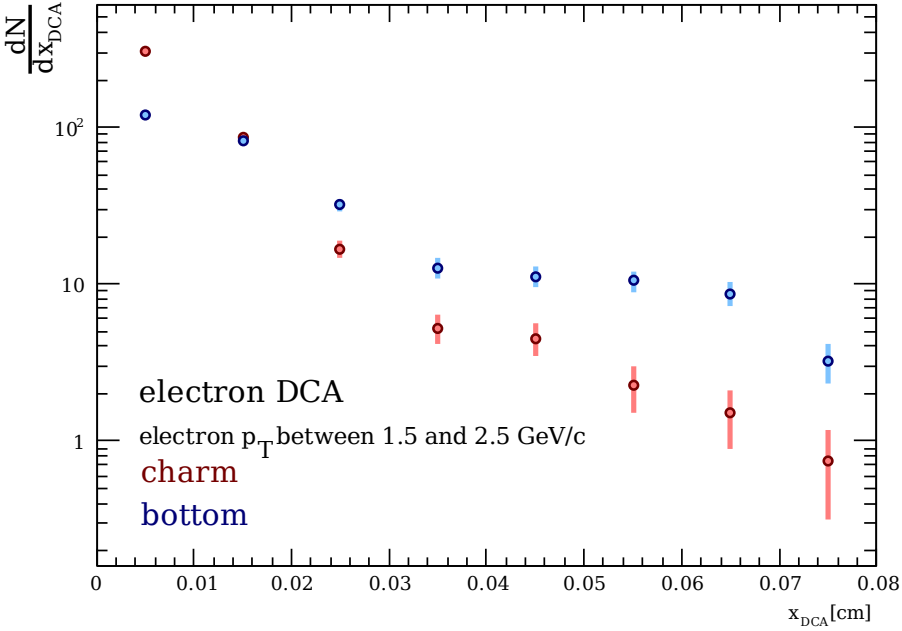
- Electron identification in PHENIX is robust, and the number of electrons per event is small.
- Matching to the central arms is simple above p_T of 1 GeV/c. The multiplicity is dominated by low p_T tracks.
- In PHENIX, most (2/3) electrons with p_T above 2 GeV/c come from heavy flavor decays.

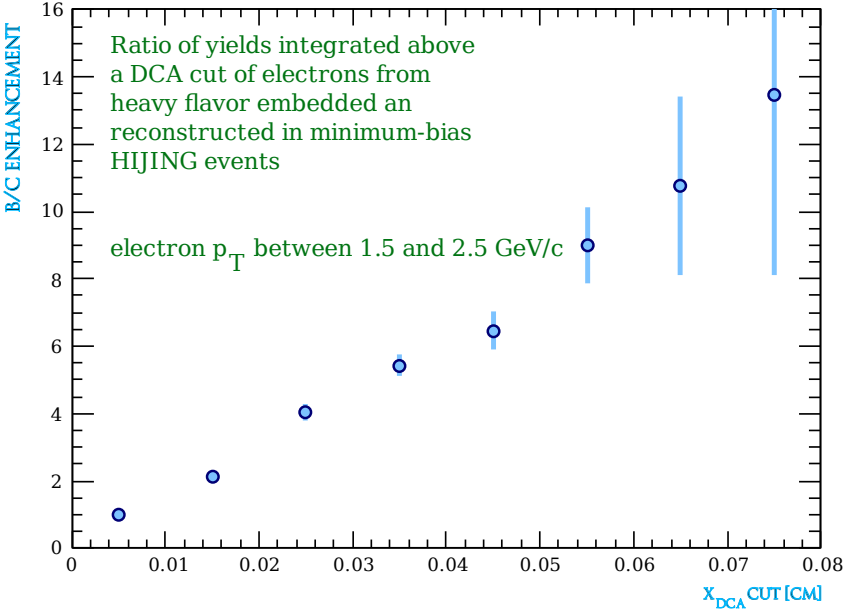


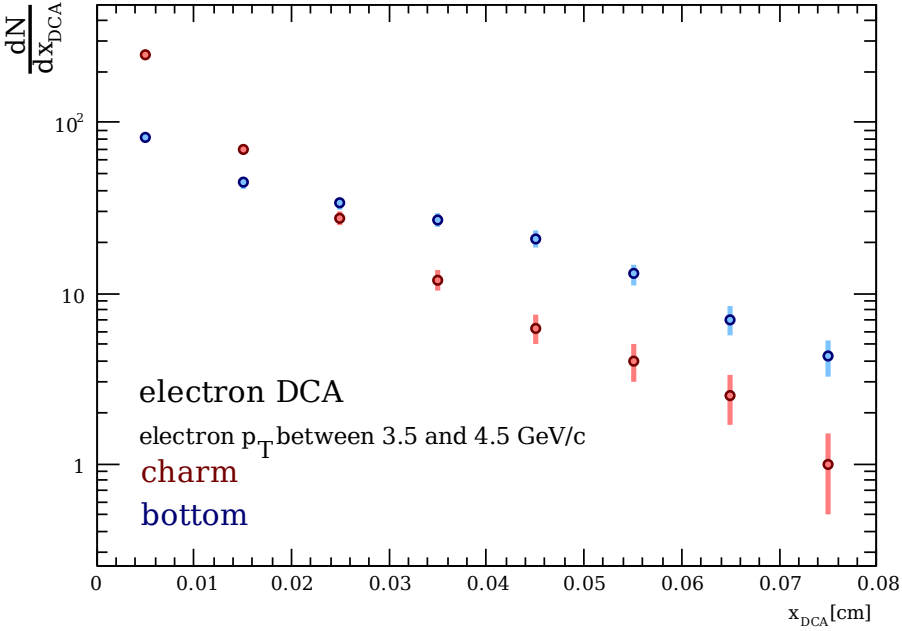
ALGORITHM

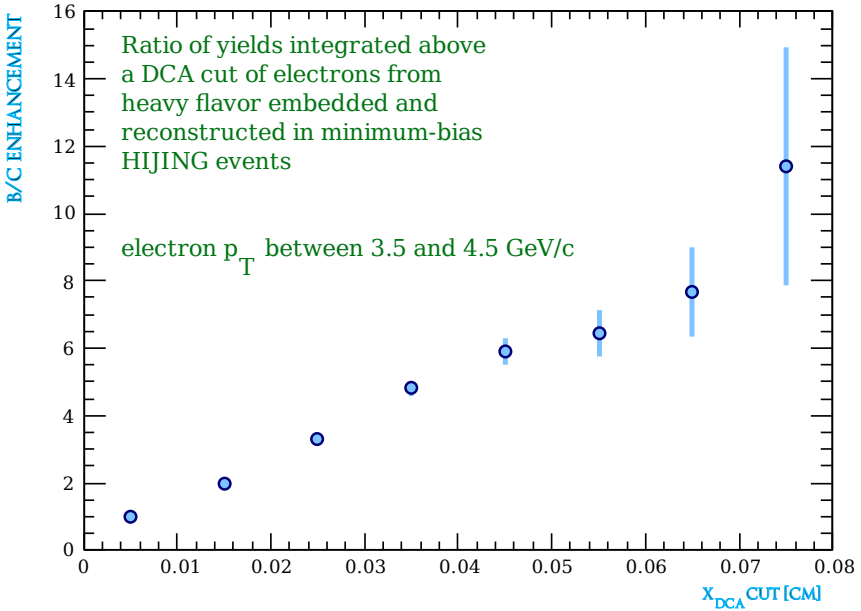
- Use simulation and knowledge of D,B kinematics to obtain dN/dx_{DCA} for decay electrons
- Measure yield of electrons integrated above a DCA cut as a function of the DCA cut
- Fit the yield vs. DCA to the known shapes for B, D, and background $e^{\pm}$


charm electrons + all charged tracks
bottom electrons + all charged tracks
dN/dx_DCA [cm]^-1
x_DCA [cm]
10^3
10^2
10
1
10^-1
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5


dN/dx_DCA
10^2
10
1
electron DCA
electron p_T between 1.5 and 2.5 GeV/c
charm
bottom
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
x_DCA [cm]


B/C ENHANCEMENT
Ratio of yields integrated above
a DCA cut of electrons from
heavy flavor embedded an
reconstructed in minimum-bias
HIJING events
electron p_T between 1.5 and 2.5 GeV/c
X_{DCA} CUT [CM]
0
2
4
6
8
10
12
14
16
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08


dN/dx_DCA
10^2
10
1
electron DCA
electron p_T between 3.5 and 4.5 GeV/c
charm
bottom
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
x_DCA [cm]


B/C ENHANCEMENT
Ratio of yields integrated above
a DCA cut of electrons from
heavy flavor embedded and
reconstructed in minimum-bias
HIJING events
electron p_T between 3.5 and 4.5 GeV/c
X_{DCA} CUT [CM]
0
2
4
6
8
10
12
14
16
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08

IF YOU BUILD IT...

In realistic simulations all the tools for c/b separation via $e^{\pm}$ are in place.

Matching between VTX tracks and central arms is easy above 1 GeV/c

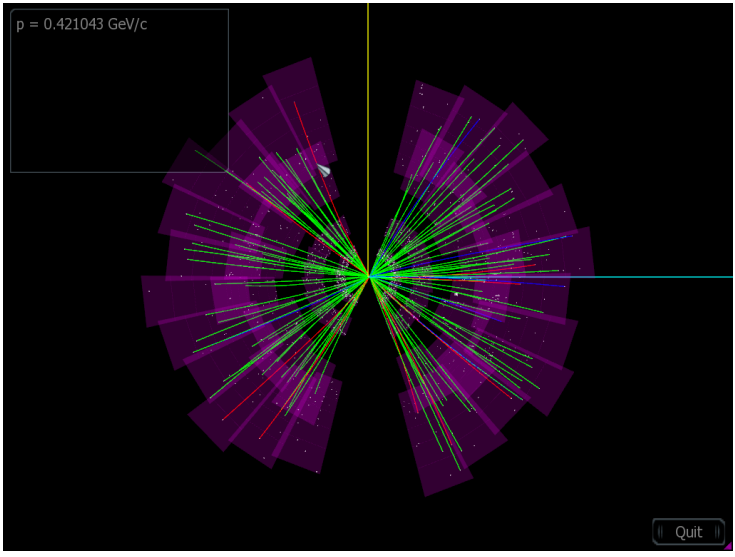
Performance does not degrade in Au+Au collisions

PHYSICS WILL COME

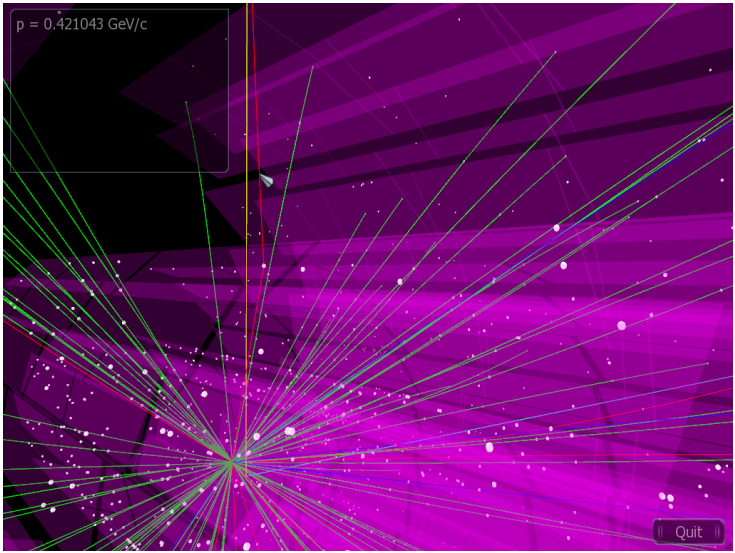
The blind analysis will have us ready for data analysis on day 1

There are other techniques to separate c & b, such as vertex multiplicity

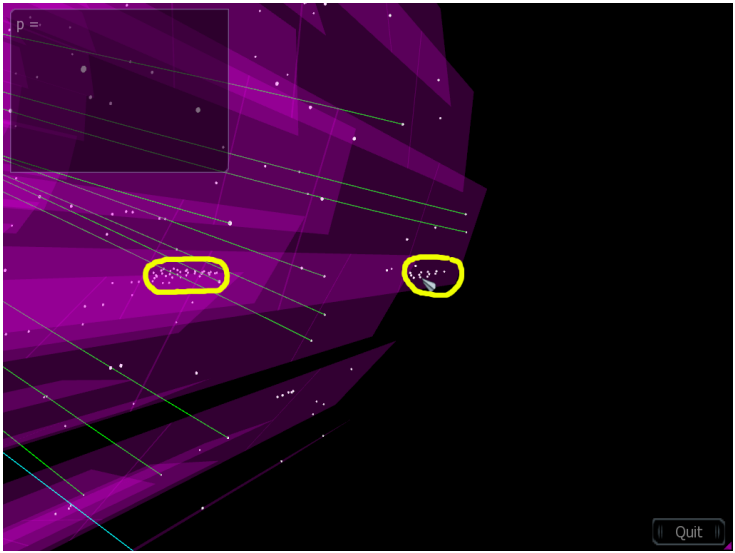
Other opportunities, such a triggering and correlating with other PHENIX upgrades, are being explored



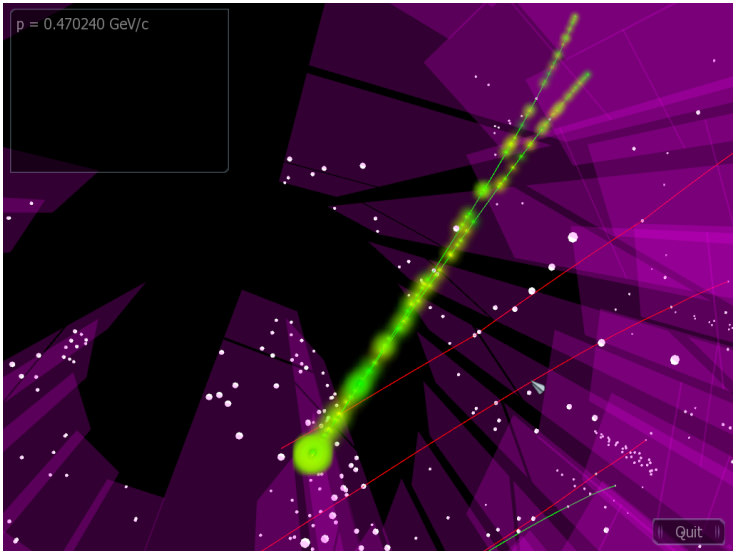
Green: properly reconstructed track. Red: MC track not reconstructed. Blue: ghost track



Note the large scatter in the 3rd layer. This track won't be reconstructed.



In high multiplicity events, curlers and noise become a nuisance.



We can reconstruct photon conversions in the beampipe and inner layer!